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The Impact of Error Avoidance on the Selection of Learning Environments

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“*I bear the wounds of all the battles I avoided*.”

Fernando Pessoa

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Abstract

People don't usually see the benefits behind committing errors, choosing to avoid situations or questions that might lead to error. Consequently, this tendency influences how we shape and select learning environments, by preferring contexts that reinforce what we already know even though that doesn't allow new learning to occur. To explore this topic, we used an implicit learning task where participants had to implicitly learn the criteria underlying target words by classifying them, along several test blocks, as following or not the criteria. During the initial classification test blocks, we manipulated whether participants could shape their learning environments. Specifically, in a mandatory-response condition, participants had to give an answer to all the trials, which was always followed by corrective feedback. In the optional-response condition, participants could choose to not answer to the trials. However, by not answering they are expected to generate a wicked learning environment since no feedback is provided to those. Thus, in a final and critical test block, where no feedback is provided and all trials had to be answered by all participants, we expected participants from the optional-response condition to have worse performances than those in the mandatory-response condition. The opposite is expected in the initial blocks, where participants in the optional-response condition could avoid answering to the trials they did not know the answer, at the cost of hindering their learning in the long run. However, our findings didn't confirm any these hypotheses. Different explanations of the obtained results and follow-up studies are discussed.

Keywords: learning environments; error avoidance; errorful learning; self-generated.

Resumo Alargado

O que é mais valioso na aquisição de conhecimento responder a uma pergunta em que sabe a resposta, ou responder a uma pergunta em que não se sabe a resposta? A reação intuitiva pode ser escolher a pergunta para qual sabemos a resposta, pois demonstra que adquirimos conhecimento suficiente para a responder. Seguindo este raciocínio, devemos evitar as questões para as quais não sabemos a resposta sendo que podemos cometer erros se o fizermos. Contudo, responder a uma pergunta para a qual já sabemos a resposta vai ensinar-nos algo de novo? Não necessariamente, responder a esta pergunta pode apenas aumentar a nossa confiança acerca da resposta. Por outro lado, se respondermos à pergunta para a qual não sabemos a resposta, tal permite-nos testar o limite do nosso conhecimento, de forma a podermos dirigir esforços em aprender mais acerca do tema. Para além disso, podemos ver até que ponto o nosso conhecimento prévio é capaz de estimar a resposta certa. Adicionalmente, ao falhar em responder à pergunta, isto permite a oportunidade de recebermos feedback acerca de qual era a resposta certa, e idealmente, porque é que essa era a resposta certa. Finalmente, isto também informa um potencial tutor/mentor/professor que precisamos de assistência com o tópico. Portanto, o processo de tentar responder a uma pergunta para a qual não sabemos a resposta, é uma oportunidade muito mais rica para a aquisição de conhecimento, pois um erro pode permitir que o ambiente forneça feedback corretivo. O exemplo dado acima pode ser visto como dois tipos de ambientes de aprendizagem. Segundo Hogarth (2001), a existência e a qualidade do feedback dependem da estrutura do ambiente em que as nossas ações e decisões ocorreram. Os ambientes de aprendizagem, por sua vez, podem ser distinguidos entre *kind* ou *wicked.* Os ambientes de aprendizagem *kind* são caracterizados por fornecerem feedback que é completo, relevante, preciso, frequente e corretivo *(*Hogarth, 2001; Hogarth, 2010; Hogarth & Soyer, 2011; Hogarth, Lejarraga & Soyer, 2015). Por outro lado, os ambientes de aprendizagem *wicked* são caracterizados por feedback que é pobre, enviesado, enganoso ou

ausente. Por estas razões, muito do que aprendemos depende do feedback que o ambiente nos fornece. Contudo, o ser humano não é simplesmente passivo e reativo durante os seus processos de aprendizagem. Hogarth (2001) postulava que os indivíduos tinham a capacidade de procurar, selecionar e moldar os ambientes em que se encontravam. Portanto, estes deviam ser proativos na procura, exposição e criação de ambientes de aprendizagem *kind*. Por outras palavras, as pessoas têm a capacidade de gerar os seus próprios ambientes de aprendizagem. Porém, para a maioria dos ambientes de aprendizagem se tornarem *kind* é primeiro necessário que se cometam erros. O problema situa-se em que a maior parte das pessoas não reconhece os benefícios que cometer erros traz (Huelser & Metcalfe, 2012), resultando numa tendência para escolher e gerar ambientes em que os mesmos possam ser evitados, criando consequentemente ambientes de aprendizagem *wicked*. Os benefícios que cometer erros traz para a aprendizagem já são conhecidos na literatura há algum tempo. Em particular, como a geração de erros acompanhada por feedback corretivo leva a uma melhor memória para respostas corretas (Kang, Pashler, Cepeda, Rohrer, Carpenter & Mozer, 2011; Kornell, Hays, & Bjork, 2009; Kornell & Metcalfe, 2014; Metcalfe, 2017). O aspeto essencial sendo o feedback corretivo, que permite que os erros sejam retificados e que deixem de persistir (Fazio, Huelser, Johnson & Marsh, 2010; Pasher, Cepeda, Wixted & Rohrer, 2005). No entanto, um aspeto que enfraquece a perceção dos benefícios do erro, são os seus componentes negativos. Afinal, ninguém gosta de cometer erros. Um destes componentes é a aversão inerente ao erro. Existe uma visão que defende que os erros são processados como ameaças endógenas, que podem causar ou colocar o ser humano em perigo (Hajcak, 2012; Proudfit, Inzlicht, & Mennin, 2013; Weinberg et al., 2016). Outro componente que justifica a evitação do erro, é o esforço. Muitas vezes antes de realizarmos uma tarefa podemos avaliá-la quanto ao esforço que vai requerer em termos de tempo, dificuldade e de probabilidade de erro. Este evitamento do esforço pode ser considerado um comportamento adaptativo, onde as pessoas escolhem e estimam as opções que requerem menos esforço para conservarem recursos cognitivos (Dunn et al., 2019; Feghhi & Rosenbaum, 2020). Neste caso, a probabilidade de cometermos erros numa situação é utilizada como pista para evitar realizá-la. O que sugere que as pessoas veem mais esforço em corrigir erros do que em evitar que estes ocorram, resultando numa escolha de contextos onde estes tenham menos probabilidade de ocorrer. Frequentemente situações na vida real salientam estes aspetos negativos do erro, contribuindo para uma perspetiva enviesada que justifica o evitamento do erro ao mesmo tempo que se ignora os benefícios que estes podem causar. O objetivo deste estudo é explorar como é que esta perceção enviesada dos benefícios do erro guiam a seleção de ambientes de aprendizagem, e consequentemente como é que isto afeta o que aprendemos. Este estudo contribuí para a literatura através do seu foco no papel proativo dos indivíduos em criar os seus próprios contextos de aprendizagem, uma criação que é, no entanto, afetada pela perceção dos benefícios que o erro tem na aprendizagem. Para explorar este tópico, utilizamos um paradigma de aprendizagem implícita. Neste paradigma, os participantes começavam por estudar palavras que partilhavam entre si um conjunto de critérios. Estes critérios nunca eram ditos explicitamente ao participante. De seguida, os participantes realizavam três blocos de teste onde tinham de classificar palavras como seguindo ou não os critérios das palavras estudadas anteriormente. Nestes blocos iniciais de classificação, nós manipulámos a capacidade de os participantes poderem selecionar o seu ambiente de aprendizagem. Especificamente, os participantes que estavam numa condição de resposta-obrigatória tinham de responder a todos os ensaios, podendo apenas responder se a palavra seguia ou não os critérios. Estas opções de resposta eram seguidas de feedback corretivo. Na condição de resposta-opcional, os participantes tinham uma opção de resposta adicional, que permitia que estes pudessem escolher não responder aos ensaios. Contudo, ao escolherem esta opção não recebiam feedback. Após estes três primeiros blocos, existia um quarto bloco de classificação, onde todos os participantes independentemente da condição eram obrigados a responder a todos os ensaios, sendo que não recebiam feedback após a sua resposta. Este quarto e último bloco servia como um último teste para averiguar o que tinha sido aprendido. Era esperado que os participantes na condição de resposta-opcional durante os primeiros três blocos apenas respondessem a ensaios em que eles tivessem a certeza da resposta, evitando aqueles em que estavam incertos ou que pudessem levar a erro. Ao realizar isto, estariam a gerar para eles próprios um ambiente de aprendizagem *wicked*, uma vez que não responder a ensaios não dava feedback corretivo. Este evitamento apesar de ter vantagens a curto prazo ia afetar negativamente a aprendizagem destes participantes a longo prazo. Consequentemente, era então esperado que os participantes na condição opcional tivessem melhores performances nos primeiros três blocos, mas no quarto e último bloco estes tivessem piores performances, quando comparados com os participantes na condição de resposta-obrigatória. No entanto, os resultados deste estudo não confirmaram nenhuma destas hipóteses. Na discussão são apresentadas diversas explicações para os dados obtidos e são apresentadas ideias para estudos futuros.

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What is more valuable in the acquisition of knowledge, to respond a question that you know the answer to or a question you don't know the answer to? The intuitive reaction might be to choose the question that you know the answer to, since it shows that you have acquired enough knowledge to be able to answer it. Following this reasoning, questions that you don't know the answer are to be avoided for they could result in errors. However, does answering the question that you already know the answer to teach you anything new? Not necessarily, it might just increase your confidence in your answer. On the other hand, the question that you don't know the answer to, allows you to test the limit of your knowledge so you can direct learning efforts towards the subject. Additionally, you can relate your past knowledge with the topic of the question and risk an answer. Furthermore, by trying and failing to answer you might have the opportunity to receive feedback on what the correct answer is, and, ideally, why it is the correct answer. Finally, it also informs a potential tutor/mentor/professor, that you need assistance with the topic. Thus, the process of trying to answer a question we don't know the answer to is a much richer opportunity for the acquisition of knowledge, since a potential mistake could allow environment to provide corrective feedback. Having said that, would you still avoid answering questions that you don't know the answer to?

This thesis is about how people perceive the benefits of committing errors and how this perception influences the creation of learning environments and ultimately what we learn. Specifically, whether people tend to avoid questions they don't know the answer to, and how this affects their learning in a final diagnostic test. The literature review presented below contextualizes how the self-generation of learning environments shapes the quality of the feedback and, consequently, the benefits that we can take from erring. Additionally, it explores how the negative aspects of error influence it's perceived benefits.

The American writer and philosopher Elbert Hubbard once wrote "the greatest mistake you can make in life is to be continually fearing you will make one". Indeed, in life there's a tendency to fear and avoid errors, as a result, we often avoid putting ourselves in situations where we might fail even though mistakes might benefit us. This tendency has its consequences for learning since it influences the type of experience and type of information we will be exposed to. A practical example of this can be found in classroom settings. Frequently, when a teacher is explaining a subject, he asks questions to the class. In these situations it's common for students to have one of two reactions: if a student knows the answer to the question and he is certain about it, he will more likely respond to the teacher; on the other hand, students that don't know the answer or aren't confident in their answer, more likely won't say anything. So, whereas students that already know the answer confirm their knowledge, students that don't know the answer or have a wrong answer but do not verbalize it, aren't corrected and aren't provided with an explanation of why the correct answer is the correct answer.

So, why don't certain students posit their answers even though they might be incorrect if it ultimately benefits their learning? As previously mentioned, we don't usually see the benefits behind making mistakes, there is even a tendency to focus on the negative aspects of mistakes (e.g., their aversiveness and effort).

Learning Environments

The example given above about the types of questions can be seen as two types of learning environments with different learning outcomes. According to Hogarth (2001), the existence of feedback and its quality depends on the structure of the environment where our actions or decisions took place. Learning environments in turn can be distinguished into *kind* or *wicked*.

Kind learning environments are characterized by feedback that is complete, relevant, accurate, timely, corrective, and frequent (Hogarth, 2001; Hogarth, 2010; Hogarth & Soyer, 2011; Hogarth, Lejarraga & Soyer, 2015). A good example of a *kind* environment is the feedback received by professional archers from their coaches - about posture, string placement, breathing, taking into an account the wind. But they also learn with their own shots, by hitting or missing a target, which are direct consequences of their actions that inform on the need of correction. Finally, they also learn from observing others – vicarious learning (Bandura, Ross & Ross, 1963). This means that in this learning environment the results of actions, decisions, and errors are directly linked to their ensuing adequacy (Hogarth, 2001; Hogarth, 2010; Hogarth & Soyer, 2011; Hogarth et al., 2015). In other words, *kind* environments enable appropriate learning for they accurately depict the situation, the task, and the obtained and desired outcomes. In this type of environment, the feedback is immediate and is informative, i.e., positive feedback indicates which responses should be maintained, whereas negative feedback signals the agent to shift or correct the response given. Furthermore, this learning environment is considered a necessary condition for the development of adequate intuitive judgments (Hogarth, 2001; Hogarth, 2010; Hogarth & Soyer, 2011; Hogarth et al., 2015).

In contrast, *wicked* learning environments are characterized by feedback that is poor, biased, misleading, or just absent (Hogarth, 2001; Hogarth, 2010; Hogarth & Soyer, 2011; Hogarth et al., 2015). The outcomes of actions and decisions in this environment are often irrelevant, leading to invalid or inappropriate learning (Hogarth, 2001). One example of this inappropriate learning is the formation of superstitious beliefs. In these, people infer wrong connections between actions and apparently related outcomes (e.g., opening an umbrella indoors is associated with a later accident; a poker player that thinks that by wearing his "lucky" bracelet will increase his chances of winning) (Eirhorn & Hogarth, 1978; Hogarth, 2001). These connections form a belief that will be resistant to testing. In the case of the poker player, the superstitious belief will not even be tested because the agent fears losing the supposed benefit attached to the belief, so he won't stop wearing his bracelet since doing so might change his luck (Eirhorn & Hogarth, 1978; Hogarth, 2001). As a result, wicked environments "teach the wrong lessons" (Hogarth, 2001), leading to dysfunctional or biased responses being systematically used due to the reinforcement of inadequate strategies (i.e., agents are encouraged to use behaviors that worked in the past) (Hogarth, 2010; Schwartz, 1982). Adding to this, intuitive judgments acquired in *wicked* learning environments are likely to be inappropriate or skewed (Hogarth, 2001, 2010)

For these reasons much of what we learn depends on the feedback that the environment provides. However, individuals aren't simply passive and reactive during their learning processes. Hogarth (2001) added that individuals can seek, select, and shape the contexts in which they are. Thus, individuals should be proactive and focus on the search, exposure, and generation of *kind* learning environments (Hogarth, 2001). In other words, individuals can self-generate their learning environments. How this self-generation affects what is learned can be best seen in the previous classroom example. Answering a question that we already know the answer to, only gives us feedback that confirms that answer, generating a *wicked* learning environment for the acquisition of new knowledge. Whereas answering a question that we don't know, even if it ends up being an error, gives us feedback that allows the correction of the response, therefore generating a *kind* learning environment associated with the acquisition of new information.

Still, for most learning environments to become *kind,* mistakes and errors are necessary. A demonstration of this is Chinese or Japanese classrooms, where teachers plan students' mistakes through specific exercises that lead to errors. Errors are used as tools to engage in active learning and to deconstruct flawed thought processes (Metcalfe, 2017; Schleppenbach, Flevares, Sims & Perry, 2007). Additionally, they inform the teacher about which students needed further assistance or what themes still weren't clear enough (Dunn & Mulvenon, 2009). However, most people don't recognize the benefits of committing errors (Huelser & Metcalfe, 2012), which might result in a tendency to choose or generate conditions that avoid error, and consequently create *wicked* learning environments.

The Importance of Error

The benefits that making mistakes have for learning have been known in the literature for some time now. In particular, how the generation of errors accompanied by corrective feedback leads to better memory for the right responses (Kang, Pashler, Cepeda, Rohrer, Carpenter & Mozer, 2011; Kornell, Hays, & Bjork, 2009; Kornell & Metcalfe, 2014; Metcalfe, 2017). Here, corrective feedback is the essential aspect that allows errors to be rectified and to stop persisting (Fazio, Huelser, Johnson & Marsh, 2010; Pasher, Cepeda, Wixted & Rohrer, 2005). Furthermore, this feedback doesn't need to be given immediately after error takes place, but it needs to be informative in regard to the correct answer (Kang et al., 2011; Pashler et al., 2005). But, critically, in many learning situations, feedback is only possible when the learner risks a response or makes an error.

An example of the benefits of generating errors is presented by Kornell and colleagues' (2009) study. In their experiment, participants saw pairs of words weakly associated with each other (e.g., factory – plant, skyscraper-tower), for a later cued recall test. The objective of the participants was to memorize target words that were presented after a weak associate. This experiment had two different conditions. In the *no-error condition*, participants studied the pairs, the cue being presented first, and the associated target word after. In the *error-generation condition*, after the participants saw the cue word, they had to guess what the target word was, which often led to an error. Following this guess, corrective feedback was provided, that is, the correct target word appeared. Afterwards, during the final cued recall test, participants answered what was the target word for each respective cue. The main finding of this study was that participants from the error-generation condition, that had failed to retrieve the target words, remembered significantly more target words in the final test than did the participants that simply studied the pairs (Kornell et al., 2009). These results have now been consistently replicated in other studies, although the benefits behind guessing seem to only occur when it's a somewhat informed guess or when the word pairs are associated or related to the target word (e.g., Fazio et al. 2010; Grimaldi & Karpicke, 2012; Huelser & Metcalfe, 2012; Kang et al., 2011; Metcalfe, 2017;).

Another important aspect that enhances learning is the source of the error, that is, who made the mistake. To study how the source of error affected learning, Grimaldi and Karpicke (2012), manipulated whether participants had the opportunity to generate their own errors, or they were simply presented with incorrect answers. The rationale behind this was to assess if the beneficial effects of error for learning were specific to the failed search for the correct answer, that is, committing errors. If learning were enhanced by the presentation of an incorrect answer, then if would mean the source of error didn't matter. The results of this experiment showed that generating errors enhanced learning, whereas being presented with an incorrect answer harmed the memory for correct answers. This suggests that self-generated errors might activate semantic structures due to the search for the right answer. Thus, it is important for individuals not to shy away from error, for they learn better when they are the ones making them.

A usual critique to the findings of error generation, is that participants in those experiments don't actually believe in their answers, they are just guessing (Metcalfe, 2017). This view assumes that real error requires a strong belief that the answer that is being given is the correct one. Additionally, this critique assumes that errors made with high confidence have a greater difficulty and resistance to being corrected (Metcalfe, 2017). In contrast to these assumptions, several studies have shown a hypercorrection effect, that is, errors made with high confidence are more likely to be corrected than low confidence errors (e.g., Butterfield &

Metcalfe, 2001; Metcalfe & Finn, 2011; Stizman, Rhodes, Tauber & Liceralde, 2015). An example of this is Butterfield and Metcalfe (2001) study, where the authors had participants respond to general knowledge questions and for each, they had to rate their confidence about the correctness of their answer. Afterwards, participants received exact feedback about the correct answer. Then, at the end of the experiment participants were retested with the same questions. What the results showed was that participants that had made wrongful but high confidence answers were more likely to correct their answer in the retest, when compared to low confidence errors. Errors made with confidence weren't resistant to being corrected. A possible explanation for these results is the surprise effect that seeing the correct answer could have in participants. Since participants strongly believed that the response they gave was the correct one, seeing that they made a mistake could rally attentional resources to remember the correct answer (Metcalfe, Butterfield, Habeck & Stem, 2012)

Although the previous studies show the advantages that making errors brings, there's still a discussion about why errors facilitate learning. Several theories have tried to explain how errors enhances memory for correct answers. One such theory assumes that errors serve as mediator cues for the right responses – the *additional-cue theory*. This theory is consistent with the difference of the benefit of error generation between weakly associated word pairs and unrelated word pairs (Grimaldi & Karpicke, 2012; Kang et al., 2011). Furthermore, Pyc, Rawson (2010) and Carpenter (2011), while trying to explain why testing helps learning, proposed that a major contributor to the testing effect could be the generation of more-effective mediational retrieval cues (e.g., words, phrases, concepts that links the cue to the target). Similarly, errors could also create cues that allow a better future recall of the target word. However, further research is needed to study if this mediation is entirely due to semantic connections or it could also rely on episodic memories of the event where the error occurred (Metcalfe, 2017).

Regarding episodic memories, the perspective of Recursive Reminding (Jacoby & Walheim, 2013) argues that the error could be a contextual aspect of the encoding situation. That is, the error and the answer could be embedded in the same episodic event. Consequently, recalling the error should facilitate the retrieval of the original episodic event. In other terms, when individuals remember the mistakes they made, they might also be able to recall the context in which they made it, and as a result, facilitate their recollection of the corrective feedback they received. This theory also implies that the memory for the correct answer should be enhanced if error is also recovered at the time of retrieval. However, Butterfield and Metcalfe (2001) showed that recalling the correct answer was independent of generating error at the time of retrieval.

On the other hand, the Reconsolidation theory makes the same assumptions as in the treatment of conditioned fears. The assumption is that to alter or eradicate a memory it first needs to be evoked (Schiller, Monfils, Raio, Johnson, LeDoux & Phelps, 2010). Following this retrieval, there's a short window of time where the memory is malleable to the influence of more adaptive responses before it becomes once again consolidated. Similarly, for errors to be corrected they need to be evoked and corrected in the reconsolidation time window. Succinctly, this allows the overwriting of the wrongful response with the correct one (Lee, 2008; Metcalfe, 2017). Therefore, this overwriting should extinct the wrong answer, making the correct answer permanent. However, in domain of conditioned fears, there are cases of spontaneous recovery of the dysfunctional response. This could imply the spontaneous recovery of error, but this needs further research (Metcalfe, 2017)

Another explanation for this effect is the idea of prediction error, as suggested by the *error correction theory* (Grimaldi & Karpicke, 2012; Kang et al., 2011; McClelland, Rumelhart, & PDP Research Group, 1986). This postulates that error enhances learning through a discrepancy between the participants' given answers and the actual correct answers.

Consequently, this discrepancy produces an error signal that guides a correction mechanism (also known as delta rule) that results in an adjustment towards the right answer. Accordingly, the greater this discrepancy is, the greater the adjustment, and consequently the learning. A consequence of this explanation is that learning does not occur when there isn't any discrepancy, that is, when there is no error (Metcalfe, 2017). An example of this could be the hypercorrection effect, where errors made with high confidence are more likely to be corrected since the participant is usually surprised with the correct answer. However, if the discrepancy in a high confidence error is lower than a discrepancy present in a low confidence error, then less learning should occur for the high confidence error (Metcalfe, 2017). This implies that further research is needed on the extent this theory can apply to error correction.

Even though, these theories still have problems explaining the full phenomenon of why error benefits learning, apparently the most difficult people to convince about these advantages seem to be the actual learners. As previously mentioned, Huelser and Metcalfe (2012), found that even though the generation of errors improved retention and learning, most participants didn’t recognize these benefits. Subjects seemed to be unaware of how helpful error generation is, also indicating that restudying the material would benefit their memory more. This lack of awareness suggests that individuals tend to see errors as evidence of a failure to learn and not as an opportunity to learn. With all the evidence of how generating errors helps learning, it is only natural to ask why people believe that making errors isn’t helpful or is even harmful?

Error Avoidance

An important aspect that undermines the perceived benefits of error are its negative components. Afterall, nobody enjoys making mistakes. These are usually defined as “acts of conduct or judgment that are misguided or wrong” (Oxford University Press, n.d), being often correlated with the occurrence of unwanted outcomes. These, in turn can depend on the context.

Whereas in a personal context errors might mean physical (e.g., a mistake while cooking might result in a cut or burn) or psychological damage (e.g., self-esteem or self-worth) (Eskreis-Winkler & Fishbach, 2019; King & Beehr, 2017;), in an educational context, mistakes can represent poor academic performance, embarrassment, or disregard by colleagues or teachers (Schleppenbach, et al, 2007; Skinner, 1953). Even in organizational contexts, there is a huge effort on preventing error, for it usually translates to economic costs, stress, damaged reputations or even injuries (; King & Beehr, 2017; Zhao, 2011). Therefore, it might seem intuitive that if one wants to avoid the negative outcomes of error, one should avoid erring.

A negative aspect of error that undermines its perceived benefits is its inherent aversiveness. There's a view that defends that errors are processed as endogenous threats, which can cause harm or put the individual in danger (Hajcak, 2012; Proudfit, Inzlicht, & Mennin, 2013; Weinberg et al., 2016). Consequently, these threats are met with adaptative and defensive responses that were once meant for external and dangerous stimuli (i.e., life threatening situations), but now respond to situations where mistakes occur (Hajcak & Fonti, 2008). Consistent with this view, errors often accompanied by the experience of distress and frustration (Spunt, Lieberman, Cohen & Eisenberger, 2012), and by physiological changes like: startle responses (Hajcak & Fonti, 2008), decreased heart rate and increased skin conductance (Hajcak, McDonald & Simons, 2004). In sum, errors are motivated-salient events that are processed as unpredictable threats and result in the elicitation of defensive motivations, negative affect, and corrective behavior (Hajcak, 2012; Proudfit et al., 2013; Weinberg et al., 2016).

This aversiveness can be modulated by several aspects. One of these aspects is the value given to error. In other words, what it means to make a mistake. This significance error has is linked to how the individual perceives the threat associated with a mistake. In turn, this value can vary with numerous aspects of a situation, for instance: if errors are punished (Meyer and

Gawlowska, 2017); if there's social scrutiny or an evaluative setting (Barker, Troller-Renfree, Pine & Fox, 2015; Hajcak et al., 2005); if errors are more "costly" than correct answers (similar to the notion of loss aversion – higher sensitivity for losses than gains) (Hajcak et al., 2005; Köbberling & Wakker, 2005); or if our mistakes might harm others (de Bruijn, Jansen and Overgaauw, 2020; Koban, Corradi-Dell'Acqua & Vuilleumier, 2013).

Another aspect that causes that affects the aversiveness of error is our subjective experience of situations. In particular, the effect of uncertainty. This construct is operationalized has the experience of doubt about whether the response given to the situation is the correct one (Pailing & Segalowitz, 2004). When there's uncertainty about the choices or judgments made, errors tend to be less aversive (Scheffer & Cole, 2000; Pailing & Segalowitz, 2004). On the other hand, the predictability of a situation and of its potential outcomes can also contribute to error aversiveness. Being in a situation that is unpredictable, or novel can decrease our ability to predict potential consequences, making mistakes more menacing (Jackson, Nelson and Proudfit, 2015; Speed, Jackson, Nelson, Infantolino & Hajcak, 2017).

An additional aspect that influences aversiveness and goes hand in hand with error is negative affect and emotionality. This can be seen in the hypersensitivity of participants that have mood or anxiety disorders and in the increased aversiveness of error when negative affect is elicited (Chiu & Delding, 2007; Ladouceur, Dahl, Birmaher, Axelson & Ryan, 2006; Proudfit et al., 2013; Wiswede, Münte, Goschke & Rüsseler, 2009).

There are also individual differences in error sensitivity, an example of this can be seen in the Implicit Theories of Traits (Dweck, Chiu & Hong, 1995; Dweck, 2006). For instance, the perceived aversiveness of error can depend on the individual's stance regarding the malleability of their traits (e.g., intelligence). *Entity* theorists consider that their traits are fixed, steady and immutable. As a consequence, they are more sensitive to error since those are perceived as intrinsic and unfixable deficits. As a result, it's expected that *entity* theorists tend to choose situations that reinforce their perception of trait, while avoiding situations that might lead them to commit mistakes (Dweck, 2006; Metcalfe, 2017). On the other hand of the spectrum, *incremental* theorists believe that traits are malleable and that any error or mistake can be compensated by controllable variables like effort and dedication. This makes incremental theorists less sensitive to error and more welcoming of learning opportunities (Dweck, 2006).

Besides error aversiveness, there is an alternative reason to avoid error: effort avoidance. Prior to performing a task, there's a tendency to evaluate its effort requirements, in terms of time, difficulty and error-likelihood (Dunn, Inzlicht & Risko, 2019). The avoidance of effort can be considered an adaptative behavior, where individuals choose and estimate options that require less effort to conserve cognitive resources (Dunn et al., 2019; Feghhi & Rosenbaum, 2020). Therefore, the likelihood of error occurring in a situation is used as a cue to avoid it. In short, there's a perception that it takes more effort and resources to correct an error than to prevent one from happening, resulting in the choice of contexts where these are less likely to occur.

There are also ways to buffer these negative aspects of error. One is by encouraging individuals to make errors and to learn from them. That can be done by emphasizing the positive effect of informative feedback, which many times errors bring along during learning episodes (Keith & Frese, 2008). Additionally, Dweck and (1998), suggest that by inducing incremental mindsets, errors could become less aversive and perceived as means to improvement. Therefore, allowing people to become more resilient and see the learning opportunities behind mistakes.

In conclusion, our perspective on error can also influenced by its negative aspects. Therefore, situations in real life can frequently highlight the threatening aspects of error contributing to a skewed view that justifies error avoidance and ignores the benefits that can come out of our mistakes.

The Current Study

The aim of the current study is to understand how this biased perception of the benefits of error guides our selection of learning environments and consequently affects what we learn. This study contributes to the previous literature due to its focus on the individual's active role in creating their learning context, a creation that is, however, affected by a skewed view of the impact that error has on learning. To accomplish this goal, we adapted an implicit learning paradigm. In particular, we used Higham and Brooks' (1997) methodology to set up the experiment.

In Higham and Brooks' (1997) first experiment, the objective was to assess participants differences in performance on classification and recognition tasks, when their level of processing was manipulated. This task used instructions analogous to standard memory conditions, while selecting materials with similar criteria to those used in artificial learning paradigms (i.e., sets of letter strings that share grammatical rules of which participants are unaware, but nonetheless become sensitive to) (Dienes & Berry, 1997; Reber, 1989). Their rationale behind the use of this type of material was to study subjects' ability to correctly discriminate words that met a set of criteria without them being able to explicitly state those criteria. The task started with a *training* phase, where participants were exposed to English words that followed three non-salient criteria: had low frequency in the language; had seven or eight letters; were all nouns. After this, they were told that the words that were studied, all followed a set of criteria. Their next task was to classify words as consistent or inconsistent with criteria the studied words followed. Critically, participants didn't know what the exact criteria the words followed, nor were they able to explicitly learn them during the task. This classification was made in a four-point scale that ranged from 1 – the word definitely isn't consistent with the criteria, to 4 - the word is definitely consistent with the criteria. Next, participants did a recognition task where they had to rate if the following words had been presented in the training phase. The words that were present in this task could be of five types: words that had been presented in training phase; words that were new and consistent with the criteria; words that were new and inconsistent with the criteria - violating one, two, or all of the criteria.

One of the advantages of using this task, is that it is riddled with error since participants don't become aware of the criteria the words follow, thinking often that they are responding at random (Cheesman & Merikle, 1984; Dienes & Berry, 1997; Higham and Brooks, 1997). Another advantage of the use of this task for the current study, is its ability to distinguish between different types of knowledge due to the presence of a mixed classification/recognition task. For instance, the classification task can determine the presence of structural learning, that is, the acquisition of tacit learning (i.e., implicit, incidental, unintentional learning) for the underlying rules of the environment (Dienes & Berry, 1997; Reber, 1989;). In this case, the structure reflects the unaware learning of the criteria that are followed by the studied words. Thus, structural learning can be seen in participants' increased acceptance of new and consistent items over new and inconsistent items (Higham and Brooks, 1997). On the other hand, the recognition component can determine the presence an episodic effect, that is, the benefit of memory for previously presented items. This effect is demonstrated by participants' better performance for old items over new and consistent items (Higham and Brooks, 1997).

The reasoning for the use of these measures is that whereas episodic effects benefit from exposure and memory, structural learning only happens if the participant engages in the discrimination/classification task. So, although participants might demonstrate an initial low performance in the task, they will improve during the experiment as they are implicitly learning the underlying structure of the task.

In the current study, in accordance with Hogarth (2001), we manipulated the possibility to generate a learning environment (*learning environment manipulation* from now on) by creating two conditions: in one participants had to forcefully respond to the task (i.e., was the word consistent or inconsistent with criteria – mandatory condition); in the second condition, a third option of response was added, allowing participants to choose not to respond to that trial (optional condition). By including this third option we can measure participants' preferences for an environment that does not benefit their learning (a *wicked* learning environment) since it does not provide any corrective feedback.

To simulate the cost that many times, in real life, is associated with errors, we added a point system (Hajcak et al., 2005; Köbberling & Wakker, 2005). In this system, errors were double as costly as gains resulting from correct answers (i.e., correct answers give 5 points, whereas wrong answers discount 10 points). Accordingly, this cost should increase the value of error and enhance the risky aspects of it.

The present task is similar to that of Higham and Brooks (1997), however a few changes were made. One of them was the splitting of the *test* phase into four blocks of trials, from which the first three give corrective feedback to participants after they respond. Furthermore, it's during these three test blocks that the learning environment manipulation takes place. Once again, this manipulation was made by adding an option of response in the optional condition. This means that in the fourth test block, all participants are forced to give an answer (i.e., no third option is included), and no feedback is given to anyone. Thus, the fourth block is a diagnostic test of what was learned.

We predict that participants that are in the mandatory condition, will show a lower performance in the first three test blocks than the ones in the optional condition, but will reveal a significant higher performance in the final test block. That is expected because the mandatory condition is a kinder learning environment due to the constant presence of corrective feedback. Accordingly, we predict the exact opposite for participants in the optional condition. A higher performance in the first three blocks but a lower performance in the final test block. The rationale underlying these hypotheses is that while participants in the mandatory condition commit a lot of mistakes during the beginning of the test blocks, these errors are followed by corrective feedback enhancing learning. In contrast, participants in the optional condition, by choosing to avoid answering questions they don't know the answer to and avoiding making errors, they are creating for themselves a *wicked* learning environment where no feedback is given. Consequently, they end up with less opportunities to learn, affecting their performance in the final test block. Thus, we hope to show how this failure to recognize the benefits of error affects the generation of learning contexts, ultimately impacting what is learned.

Method

Participants

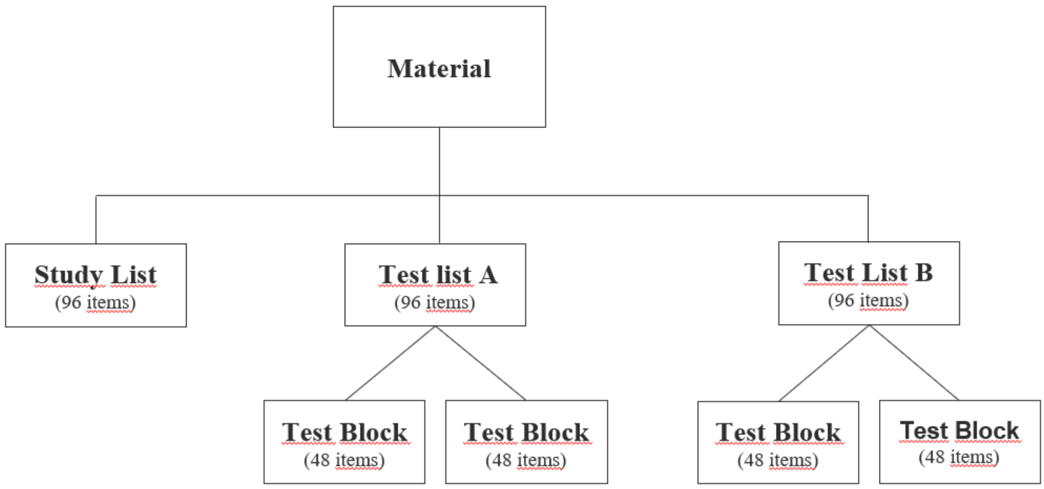
Seventy-nine participants were recruited from the subject pool of the "Social Cognition and Learning" research group using ORSEE (Greiner, 2015). Three participants were excluded from the analyses as they dropped out halfway through the experiment. Therefore, the final subject pool was of 76 participants (50 females, M_{age} = 25.21, SD = 5.96). All participants were Portuguese native speakers and were 18 years old or older. In exchange for their collaboration, subjects received a 10 euros voucher, with the possibility of an additional 5 euros bonus for those with the highest performance in the subsequent experiment. Two participants received this bonus for accumulating 825 points. This study was approved by the Deontology Commission of the Faculty of Psychology at the University of Lisbon (FP-UL).

Materials

The material used in this experiment consisted of a study List and two test Lists (see figure 1, to see the distribution of the material). All the items used in these lists were taken from the SUBLEXT-PT lexical corpus (Soares et al., 2015), and were selected according to the criteria used in Higham's and Brooks (1997) first experiment. These items were not translations of the items used by Higham and Brooks (1997), but they met the same criteria in the Portuguese language. The three criteria are: nouns (abstract or concrete); with a length of 7 to 8 letters; with low frequency (less than 50 occurrences per one million words).

Figure 1

Organogram concerning the list and item distributions in the experiment



Study List

The study list consisted of 96 words, all following the previously mentioned criteria (see Appendix A for the composition of the study list). The presentation of these items was randomized.

Test Lists

There were two test lists (list A and list B), with two blocks each (see Appendix B and C for the composition of list A and B). These lists could be presented in one of two possible orders depending on participants' condition (Order AB; Order BA). Together, the test lists were divided into four blocks, making it 192 items in total (see figure 1). Of those 192, half followed the criteria used in the study list (*consistent* words from now on), whereas the other half did not meet one or more criteria of the Study List (*inconsistent* words from now on).

Specifically, each block had 48 items and was composed of 5 types of items: 16 items that were presented in the study list (*old – consistent*); 8 were new items that met all the criteria (*new – consistent*); 8 were new items that violated the frequency criteria (i.e., high-frequency nouns with 7 to 8 letters) (*new – inconsistent violated one criteria*); 8 were new items that violated the frequency and length requirements, (i.e., high-frequency nouns with 5 to 6 letters) (*new – inconsistent, violated two criteria*); 8 were new items that violated the frequency, length and noun criteria (i.e., high-frequency verbs with 5 to 6 letters) (*new – inconsistent, violated three criteria*). Thus, in each block, there were 24 consistent and 24 inconsistent items.

All these items were randomized within each list, but not between lists. Consequently, no items were presented in both lists (not even the repeated items from the study list)

Procedure

The experiment took place in the laboratories of the Psychological Science Research Center (CIPSI) at the Faculty of Psychology. It lasted on average 24 minutes, and each session had between eight to ten participants. This experiment was presented to the participants' as a word classification game where their objective was to accumulate as many points as possible. Those who accumulated more points would receive 5-euro bonus voucher.

The experiment had two phases: a study phase – where participants studied a list of items that belonged to a category ("List Category"); and a test phase – where participants had to decide whether a set of items belonged or not to the "List" category. Accordingly, all participants in the study phase were informed that they were going to see several words on screen, belonging to a category called "List" (see Appendix D, for the instructions of this phase). Their task was to read them carefully, each word remained on screen for 3 seconds.

Afterwards, in the test phase, participants started by reading a set of instructions regarding the rules and objectives that section of the "game" had. Respectively, they were told that the test phase was composed of four blocks of trials. In each, they would see several words, some of them that had been previously seen in the study phase. Their task during those four blocks would be to decide whether those words belonged or not to the "List" category (i.e., whether they shared the same set of characteristics). Additionally, during this phase, participants could be in one of two conditions (mandatory vs. optional) (see Appendix E, for the exact instructions of each condition). Participants in the mandatory condition were required to indicate in each trial of the first three blocks, whether the target word belonged or not to the "List" (i.e., they had to select one of two options: "List category" or "other category"). In the optional condition participants had the option of choosing a third response, that enabled them to skip the trial without answering (i.e., "I don't know/ I don't want to respond"). The rationale of having this condition was, as mentioned before, to give participants the ability to generate their own learning environment (*kind* vs. *wicked*). Consequently, it is expected that participants will be affected by their default mindset of avoiding error, choosing more often *wicked* learning environments (i.e., not answering in trials they do not know the answer) when they have the possibility to do so. On the other hand, participants in the mandatory condition are forced to respond to all of the trials and to receive feedback from their answers, turning it into a forced, but *kind* learning environment.

Furthermore, participants were informed about the point system in place. If they chose correctly whether a word belonged or not to the "List Category", they received 5 points. However, if they classified a word incorrectly 10 points would be discounted to their accumulated amount. Correspondingly, the logic to use this point system was to increase the significance of error, since mistakes "costed" more than right answers. It was therefore expected that participants in the optional condition would only respond to trials they were certain about, avoiding those they were not certain of. While this option allows them to reach a better score, it can also hinder their learning since no feedback is provided for the trials they choose not to respond to (i.e., option "I don't know/ I don't want to respond").

After reading these instructions, participants performed 3 training trials where the task was demonstrated without points being added or discounted.

While performing the test blocks, each participant went through 48 trials. In each, the participants viewed a word and provided a self-paced answer. After each trial, participants received feedback on the accuracy of their answers (i.e., correct vs. incorrect) along with the score obtained in the trial (i.e., whether they had gained 5 points or lost 10 points). It is important to note that, the feedback given to participants when they classify the word is considered corrective feedback, for they can infer what the answer was from their response (Eskreis-Winkler & Fishbach, 2019). Nevertheless, in the optional condition, no feedback was provided when participants chose to not answer (i.e., option "I don't know/ I don't want to respond), they were only informed that they had neither gained nor lost any points (see Appendix F for the feedback after each option).

Additionally, in this phase the order of the test lists was manipulated. Depending on the condition the participants were in – order AB vs. order BA – they would either start by performing the two blocks of List A and finish with two blocks of list B or the opposite. These conditions served as material checks for the adaptation of words in the Portuguese language. Therefore, participants could be in one of the four conditions: Mandatory Order AB; Mandatory Order BA; Optional Order AB; Optional Order BA.

At the end of each test block, participants were informed of the number of points they had obtained, as well as the maximum and minimum points they could have reached in that block (Appendix G to see the scoring tables - end block feedback). Throughout the blocks, these values changed, counting not only the score obtained in each separate block and the accumulated points so far, but also the maximum and minimum possible scores (i.e., these values corresponded to the best and worst possible scores participants could have, had they hitted or missed every trial so far).

After the third test block ended, participants received instructions regarding block four (see appendix H, for the exact instructions). This last block was similar to the previous ones, yet it had two differences: 1) No feedback was provided to participants; 2) participants in the optional condition wouldn't no longer have the option to choose the "I don't know/ I don't want to respond". Thus, this last block is equal for participants in both conditions, and it is the block that tests the learning that took place during, not only the study phase, but also the test blocks. As mentioned in the hypotheses, we expect that participants in the mandatory condition will have a better performance here, since they were forced to respond and had to learn from their mistakes and consequent feedback.

Having completed the last test block, participants answered two questions about their performance (Appendix I, for the questions). First, they had to estimate their performance in the last block on a 5-point scale, that ranged from "Very bad" to "Very Good". Next, participants saw a spread sheet with the minimum and maximum of points they could have accumulated in the "game" and were asked to estimate their score during the fourth test block.

Afterwards, they were provided with their attained score and the score had they got right or failed every single trial, similar to previous end block scoring tables (see Appendix G to see the scoring tables - end block feedback.

Finally, the participants indicated their gender and age, were thanked for their participation, and had a space for comments or suggestions they had regarding the experiment. This experiment was run through the Online Survey Platform – Qualtrics (Qualtrics, Provo, UT).

Results

The statistical analyses reported below were conducted using IBM SPSS Statistics for Windows, version 26.0 (IBM, 2017).

In Table 1, we present the response accuracy across test blocks, for participants in the mandatory and optional conditions. The accuracy was calculated by dividing hits by the amount of trials the participant answered. In the optional condition hits were divided by the total amount of trials minus the trials that the participant didn't respond to (i.e., chose third option "I don't know/ I don't want to respond"). This meant that participants' accuracy in the mandatory condition was calculated using the totality of trials, whereas the same is not true for the optional condition. Therefore, all scores should vary between 0 and 1, and participants with the accuracy of .50 indicate that their performance was equal to chance (i.e., the participant was responding at random).

Table 1

Means and Standard Deviations for Accuracy as a Function of the Learning Environment Manipulation across Test Blocks.

Possibility	Test Blocks							
	Block 1		Block 2		Block 3		Block 4	
	M	SD	M	SD	M	SD	M	SD
Mandatory	.434	.072	.415	.070	.405	.067	.379	.058
Optional	.449	.090	.446	.110	.420	.117	.369	.079

To assess the differences in participants' final performance during Test Block 4 (i.e., when no feedback was given and all participants were forced to answer to all trials), a Two-Way ANOVA was performed. Accuracy was the dependent variable whereas the learning environment (mandatory vs. optional) and version (order AB vs. order BA) were the two between-subjects independent variables. We expected a main effect of the learning environment manipulation and no main effect of order of material or of the interaction. No significant main effect of the learning environment manipulation was found, $F(1, 72)=.063$, $p=.803$, $\eta_p^2=.017$. This analysis also didn't show a main effect for the order of material $F(1, 72)=1.253$, $p=.267$, $\eta_p^2=.001$, suggesting that the two versions of material did not lead to differences in the participants' accuracy. Finally, no significant interaction was found, $F(1, 72)<.001$, $p=.983$, $\eta_p^2<.001$.

Next, a chi-square test of independence was conducted to see if the amount of "no responses" in the optional condition were significant. What this tells us is whether the manipulation of the learning environment worked. The test suggests that the learning environment manipulation failed, $\chi^2(1, N= 76) = .053, p = .818$, since no significant differences were found between the mandatory and the optional conditions. In other words, participants in the optional condition didn't choose the third option (i.e., "I don't know/ I don't want to respond") enough times to make it a distinct condition.

A Mixed Effects ANOVA was conducted to assess the replication of results obtained by Higham and Brooks (1997). This ANOVA will inform us on the presence of structural learning and episodic effects in participants' performance. Here, the dependent variable is the rate of participants' acceptance of items into the "List" category (i.e., choose option "LIST Category") in the fourth block, and the independent variables are the learning environment manipulation (mandatory vs. optional) and the type of item (old vs. new consistent vs. new inconsistent items that violate one of the criteria vs. new inconsistent items that violate two of the criteria vs. new inconsistent items that violate all three criteria). Whereas the learning environment manipulation was a between-subjects variable, the type of item was within-subjects. Again no significant main effect of the learning environment manipulation was found, $F(1, 74) =.163, p=.687, \eta_p^2 =.002$. There was, however, a main effect of type of item, $F(1, 74) =10.859, p<,001, \eta_p^2 =.128$.

Furthermore, Planned Contrasts were conducted to test if participants revealed structural learning (i.e., had learned the implicit criteria) or episodic effects (i.e., remembered the items presented on the study list – old items). For the presence of structural learning, a contrast was conducted between participants' acceptance of consistent items (old and new) and inconsistent items (missing one, two, or all of the criteria). This meant that the acceptance of consistent items was considered as hits, and the acceptance of inconsistent items as false alarms. Unexpectedly, a significant but negative difference was obtained leading to the rejection of the null hypothesis, $F(1, 74) = 15.824$, $p < .001$, $\eta_p^2 = .176$, with participants accepting more inconsistent items (violated one criteria, $M = .889$, $SD = .019$; two criteria, M =.922 , SD =.018; violated three criteria, $M = .889$, $SD = .022$) than consistent ones ($M = .762$, $SD = .030$).

A second contrast was conducted between participants' acceptance of old items and new consistent items, to test for the presence of episodic effects. The contrast showed a significant difference, $F(1, 74) = 17.224$, $p < .001$, $\eta_p^2 = .189$, meaning participants did accept more old items ($M = .852$, $SD = .017$) than new consistent ones ($M = .762$, $SD = .030$), showing an episodic effect.

Finally, a Pearson correlation was calculated between participants' estimation of their performance and their actual performance (in points) in the final test block. Here, a positive and moderated correlation was found, $r(74) = .589$, $p < .001$., indicating that participants could predict their performance in the last test block.

Discussion

People don't usually see the benefits behind committing errors, choosing to avoid situations or questions that might lead to an error (Huelser & Metcalfe, 2012; Metcalfe, 2017; Schleppenbach et al., 2007). Consequently, this biased perception of error could influence how we shape the environments we are in, creating situations that reinforce what we already know, even though that doesn't allow for new learning to occur. Often to acquire novel information it is necessary to err so corrective feedback can be provided, that is, a kind learning environment is required (Hogarth, 2001).

The main objective of this study was to explore how a biased view on the benefits of error for learning, impacted people's selection of learning contexts (Hogarth, 2001; Metcalfe, 2017). To accomplish this, we used an implicit learning task where participants had to learn to discriminate between words that met a set of criteria and words that didn't. This task involved an initial study phase, where participants saw words that followed three criteria (i.e., nouns, with 7 to 8 words of length and low frequency in the language). This was followed by a test phase split into four test blocks. In these blocks' participants classified words as belonging to a category that met the criteria ("List category") or as belonging to another category that didn't meet those criteria ("Other category"). During the first three test blocks participants received feedback on their answers. However, in the fourth and last test block this feedback seized, serving, thus, the purpose of a final diagnostic test for the learning participants had acquired.

All these test blocks also had a point system in place, were errors were costlier than right answers. Correct answers gave 5 points to the participants, whereas wrong answers discounted 10 points from the accumulated score. Participants that had the most points at the end of the study would receive a 5-euro bonus. Additionally, we manipulated whether participants could shape their learning environments or not (Hogart, 2001). This manipulation was only present in the first three test blocks, the final test block being the same for all participants. It consisted of giving the participants an additional option of response that allowed them not to answer to trials (i.e., the option "I don't know/ I don't want to respond"). In the mandatory condition participants didn't have this option, being forced to answer to all of the trials, in an imposed kind environment.

It was expected that participants in the optional condition would frequently choose not to answer due to the high uncertainty underlying the implicit learning task (Feghhi & Rosenbaum, 2020; Hajcak & Fonti, 2008; Weinberg et al., 2016). Choosing this option frequently was expected to lead to a wicked feedback-free environment and, as such, to have a more negative impact on learning, when compared with a condition where participants answered to all trials. As a result, we also expected that this avoidance to answer trials they were uncertain about, would increase participants' scores and accuracy during the first three blocks, when compared with the mandatory condition, since they would more likely only respond to trials they knew the answer to. Critically, it was expected that the self-generation of a *wicked* environment would negatively impact participants' performance on the last test block, since they had less opportunities and less feedback for the acquisition of the implicit criteria. Moreover, we also hypothesized that participants in the mandatory condition would have lower scores in the first three blocks but better scores in the final test block when compared to those in the optional condition. The logic behind this hypothesis was that participants in the mandatory condition are forced to answer to all trials, making a lot more errors, but also benefitting from the feedback of this imposed *kind* learning environment. This feedback would allow participants to implicitly learn the criteria the words followed, improving their performance in the fourth test block.

Surprisingly, none of these hypotheses were confirmed. Some plausible explanations for this finding are discussed next. The most plausible explanation is the failure of the learning environment manipulation, which translates into participants in the optional condition not choosing the third option of response enough times do make it a distinct condition. Consequently, participants went through very similar, supposedly kind learning environments.

One of the reasons why participants, in the optional condition, might have chosen to answer trials more often than we expected, could be due to an imprecise formulation of the third option. The "I don't know" part of the "I don't know/I don't want to respond" option, could have been interpreted by participants as acknowledging or confessing to the researcher their inability to correctly answer a trial, which in an experimental setting might mean they did not pay enough attention to the material. Thus, choosing any of the other two options (i.e., "List category", "Other category") had a lower risk of being wrongly interpreted and/or of showing ignorance. A way to correct this limitation would be to alter the third option so it only implies skipping the trial (e.g., “Skip this trial”). This would improve the strategic use of the response to get the most points. Another solution could be giving participants the choice of answering or skipping the trial before seeing the response options ("List category", "Other category"). If they chose to skip the trial, they wouldn't receive any feedback, moving forward to the next trial. This solution allows a separation between deciding to skip the trial and deciding what the answer to the trial is. Both these solutions would permit participants to strategically decide when not to respond.

In accordance with the previous explanation, if participants associated the third option with showing ignorance, this could make the third option the most aversive of the options (Hajcak, 2012). A major modulator of error aversiveness is its significance, how the individual perceives the threat associated with a mistake. This value of error can depend on the characteristics of a situation: if errors are punished or rewarded; if they are more costly; if it’s an evaluative setting; or if errors harm others (Hajcak et al., 2005; Meyer & Gawlowska, 2017). In this case, if participants perceived the third option as showing ignorance to the researcher, it could make the third option the most aversive out of the three options of response. This aversion could justify participants disregard for the third option, since the consequences of response were perceived as the worst (Hajcak & Foti, 2008; Hajcak, 2012; Weinberg et al., 2016). However, this also implies that the participants value more not being perceived as ignorant than the 5-euro bonus.

A further contributor to this decreased value of error could be the task inherent uncertainty. Most participants during implicit tasks are unaware of the criteria that the words follow, meaning that participants tend to doubt about whether their responses were the correct ones (Cheesman & Merikle, 1984; Dienes & Berry, 1997; Scheffers & Cole, 2000; Pailing & Seglowitz, 2004). This uncertainty was shown to decrease the aversiveness of errors, especially if it's due to a lack of information (Pailing & Segalowitz, 2004).

Another possible reason for the rare use of the third option could be because of participants' lack of motivation, which might have been caused by a few factors: the nature of the task; its extended duration; or because of frequent negative feedback. Firstly, as mentioned before, implicit tasks are riddled with uncertainty since participants usually think they are responding randomly (Cheesman & Merikle, 1984; Dienes & Berry, 1997). Consequently, this uncertainty could affect participants' motivation to perform the task, since they were most of the times unsure of their answers. Adding to this, the prolonged duration and repetitive character of the task could contribute to this lack of motivation (Dunn, Inzlicht & Risko, 2019). Lastly, frequently receiving negative or failure feedback (i.e., "Your answer is wrong") could also hinder participants' motivation and undermine learning. Recently, Eskreis-Winkler and Fishbach (2019) research demonstrated that failure feedback (i.e., "incorrect response") sabotaged participants' learning motivation when compared to success feedback (i.e., "correct response). This hurtful effect of feedback on learning was mediated by participants' ego, suggesting that failure feedback harmed participants' self-esteem, causing them to tune out of the task and to stop processing information.

This lack of motivation could also justify the failure to replicate the results obtained by Higham and Brooks (1997) in terms of structural learning. Participants in our experiment didn't learn the implicit criteria that the words followed. Here, participants' lack of motivation during the task could have made them tune out of the task, undermining their attention and information processing, primarily the processing of feedback. Without feedback being processed, there is less integration of the new information into memory, which hurts any potential improvements in performance (Anderson, Kulhavy & Andre, 1972; Metcalfe, 2017). This would explain why participants weren't able to acquire the task underlying structure, having poor performance even in the final test block. Another explanation for the absence of structural learning could be due to the criteria the words followed. These criteria could be less salient in the Portuguese language. For example, on average, the words in Portuguese have more syllables and variability than English words. This can might decrease the salience of three-syllable words.

One of the ways to improve this study would be to apply an awareness measurement at the end of the experiment, to verify participants' knowledge of the implicit criteria (Dienes & Berry, 1997; Stadler, 1997). The presence of this test would ascertain if participants used any explicit strategies that could have affected their performance and see if the material's format (e.g., semantic connection between Portuguese words) could have harmed their scores (Frensch, 2003). Moreover, something important that could have been done was the implementation of attentional checks during the task to ensure participants were processing information.

Future Concerns and Concluding Remarks

Regarding future studies we consider that any replications of this study should implement the improvements suggested above, mainly the reformulation of the third option of response, so it isn't interpreted as ignorance. Additionally, they should manipulate the significance of error. This could be done, either by making the point system have direct value in monetary gains and losses, or by introducing more aversiveness to the task, such as aversive sounds (Hajcak et al., 2005; Meyer & Gawlowska, 2017).

Another important aspect of future replications should be the use of different materials. It is possible that participants could have focused on apparent semantic connections between words thinking they were the criteria, consequently harming their performance (Fresnch, 2003). Therefore, future studies should use materials that aren't semantically related in any way but that also possess implicit criteria. Another possibility is to use visual, more abstract criteria (e.g., geometric shapes). Additionally, a future study should have multiple levels of difficulty regarding the implicit criteria. This controls having criteria that are easier or more difficult for participants to learn.

A future study could also explore the relationship between implicit theories of traits (Dweck, Chiu, & Hong, 1995) and this tendency not to see the benefits behind erring. Therefore, investigating how individual differences in error sensitivity affect the generation of learning environments.

An additional test that could be done in the future would be a pretest of the feedback to ensure that its format doesn't harm participants' performance (Eskreis-Winkler & Fishbach, 2019). This could be achieved either by only giving feedback to half of the participants, by giving neutral feedback independent of the answer so it doesn't focus on the error (e.g., "The correct answer was:…"), or by adding information to the feedback. Specifically, the probability of success and failure of each trial could be added to the feedback. For example, after a participant had gotten a wrong answer, they could either see: "Your response was wrong! 2% of participants responded correctly to this question".; or see "Your response was wrong! 87% of participants responded correctly to this question". This manipulation of the likelihood of other participants getting the answer right or wrong could control the harmful consequences of receiving failure feedback, therefore allowing the verification of its consequences for learning.

In conclusion, although the present study wasn't able to show how a skewed view of error impacted participants' generation or selection of learning environments, it discusses the importance of studying individual's proactive role in selecting their own learning contexts. Most of the previous research focuses on individual's passive role, recognizing only how environments shape us but not how we shape or should shape our environment for a better learning (Hogarth, 2001). Finally, we suggest, that further studies should inspect how this imperfect creation and selection of environments is a result of our biased view.

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Appendix A
Item composition of the study list

absurdez	anchova	brânquia
anamnese	arterite	calcite
anuência	ateísta	chaparro
aspersão	beatice	comisso
autómata	brâmane	diálise
bimotor	cabresto	encarte
brasuca	castelã	espadim
canoeiro	cominho	flotilha
charola	copianço	galocha
congote	eclosão	guedelha
diurese	errância	incúria
eremita	flâmula	livrete
estopada	frémito	louceiro
formanda	grafismo	marreca
geladura	idólatra	milonga
ideólogo	litíase	naifada
jaquetão	losango	obreiro
locução	maresia	paredão
lupanar	milhafre	pêndulo
mastaba	mutação	poupador
morcela	nevrose	pugilato
negrada	pancadão	retorta
opereta	pedículo	sarcoma
peculato	pisadela	taoísmo
pequenez	propanol	tirosina
predação	remendão	vendeiro
punidor	sanfona	zoóloga
sabugal	sumidade	aselhice
sicrano	tigelada	autarca
tapeação	uretrite	berloque
tomador	virador	
vinhaça	amaragem	
aletria	antúrio	

Appendix B
Item composition of the test list A

Old items

absurdez	anamnese
anuência	aspersão
autómata	bimotor
brasuca	canoeiro
charola	congote
diurese	eremita
estopada	formanda
geladura	ideólogo
jaquetão	locução
lupanar	mastaba
morcela	negrada
opereta	peculato
pequenez	predação
punidor	sabugal
sicrano	tapeação
tomador	vinhaça

New and consistent items

açoteia	apanágio
azagaia	bravata
colóquio	doceira
falácia	gerbera
lampreia	mancheia
morgada	palafrém
périplo	ramagem
sudário	traquete

New and inconsistent items (violated one criteria)

atenção	certeza
conselho	dinheiro
espécie	história
licença	loucura
momento	polícia
pressão	relação
sargento	silêncio
sucesso	unidade

New and inconsistent items (violated two criteria)

bocado	buraco
carta	classe
época	guerra
hotel	janela
marido	mundo
ordem	papel
rainha	razão
senhor	tempo

New and inconsistent items (violated three criteria)

aberto	ajudado
trazido	chamado
dançado	mantido
esperado	subido
gostado	lembrado
ligado	morrido
roubado	podido
sentado	tentado

Appendix C
Item composition of the test list B

Old items

aletria	anchova
arterite	ateísta
beatice	brâmane
cabresto	castelã
cominho	copianço
eclosão	errância
flâmula	frémito
grafismo	idólatra
litíase	losango
maresia	milhafre
mutação	nevrose
pancadão	pedículo
pisadela	propanol
remendão	sanfona
sumidade	tigelada
uretrite	virador

New and consistent items

alegrão	arrebol
balastro	brônquio
comadre	dualismo
faringe	germânio
laranjal	mansidão
mosqueta	palmanço
pieguice	rebarba
sulfato	triplano

New and inconsistent items (violated one criteria)

cérebro	cerveja
criança	energia
exemplo	hospital
ligação	mensagem
planeta	porcaria
princesa	repente
senhora	sistema
tribunal	vergonha

New and inconsistent items (violated two criteria)

braço	cabeça
casaco	corpo
escola	homem
imagem	líder
morte	noite
padre	prisão
rapaz	sangue
série	vítima

New and inconsistent items (violated three criteria)

acabado	atirado
bebido	chegado
deixado	escutado
evitado	ficado
havido	levado
mandado	odiado
pegado	sabido
pensado	voltado

Appendix D
Instructions given during the study phase

Bem-vindo/a!

Vai participar num jogo de classificação de palavras. Este jogo é constituído por várias fases e o seu objetivo é chegar ao final do jogo com o máximo de pontuação possível. Para tal, deverá seguir atentamente todas as instruções que lhe forem dadas ao longo do jogo.

Clique em --> quando estiver pronto/a para começar a primeira fase do jogo.

Início do jogo

Vamos começar por lhe apresentar uma lista de palavras pertencentes à **categoria LISTA**. Por pertencerem a esta categoria, todas as palavras apresentadas partilham um conjunto de características. A sua tarefa nesta fase do jogo será apenas ler atentamente todas as palavras apresentadas.

Caso tenha alguma dúvida, coloque-a agora ao experimentador. Quando estiver pronto/a para começar a apresentação da lista clique em -->

Appendix E

Instructions given in the test phase, for each condition of the possibility to generate a learning environment.

Mandatory condition

REGRAS E OBJETIVO

Esta fase é constituída por um jogo experimental que contém 4 blocos com várias jogadas. O objetivo é alcançar o máximo de pontos em cada bloco. O/a participante que obtiver a melhor pontuação no final do estudo receberá como prémio um voucher adicional no valor de 5€.

Em cada bloco vamos apresentar-lhe uma nova lista constituída por palavras pertencentes à categoria LISTA e palavras de outras categorias. Em cada jogada, a sua tarefa será indicar se a palavra apresentada pertence à categoria LISTA ou a outra categoria.

Lembre-se que para pertencerem à categoria LISTA as palavras têm de partilhar um conjunto de características com as palavras que lhe foram anteriormente apresentadas. É provável que nas primeiras jogadas tenha alguma dificuldade em indicar corretamente quais as palavras que pertencem à categoria LISTA. No entanto, à medida que o jogo avançar esta dificuldade tenderá a diminuir.

PONTUAÇÃO

No final de cada jogada receberá uma pontuação em função da acuidade da sua resposta: sempre que categorizar corretamente uma palavra receberá 5 pontos, sempre que errar na sua resposta perderá 10 pontos.

No final de cada bloco receberá ainda um resumo comparativo da pontuação obtida até ao momento com os valores mínimo e máximo que poderia ter acumulado se acertasse ou errasse em todas as jogadas do bloco.

Lembre-se que o/a participante que obtiver a melhor pontuação no final do estudo receberá um voucher adicional no valor de 5€!

Para se familiarizar com a tarefa, vamos apresentar-lhe de seguida 3 jogadas de treino.

Optional Condition

REGRAS E OBJETIVO

Esta fase é constituída por um jogo experimental que contém 4 blocos com várias jogadas. O objetivo é alcançar o máximo de pontos em cada bloco. O/a participante que obtiver a melhor pontuação no final do estudo receberá como prémio um voucher adicional no valor de 5€.

Em cada bloco vamos apresentar-lhe uma nova lista constituída por palavras pertencentes à categoria LISTA e palavras de outras categorias. Em cada jogada, a sua tarefa será indicar se a palavra apresentada pertence à categoria LISTA ou a outra categoria. Nos primeiros 3 blocos poderá ainda optar por passar à jogada seguinte sem escolher nenhuma das categorias, selecionando a opção "não sabe/não responde".

Lembre-se que para pertencerem à categoria LISTA as palavras têm de partilhar um conjunto de características com as palavras que lhe foram anteriormente apresentadas. É provável que nas primeiras jogadas tenha alguma dificuldade em indicar corretamente quais as palavras que pertencem à categoria LISTA. No entanto, à medida que o jogo avançar esta dificuldade tenderá a diminuir.

PONTUAÇÃO

No final de cada jogada receberá uma pontuação em função da acuidade da sua resposta: sempre que categorizar corretamente uma palavra receberá 5 pontos, sempre que errar na sua resposta perderá 10 pontos. Nas jogadas em que optar por não responder, não receberá nem perderá pontos.

No final de cada bloco receberá ainda um resumo comparativo da pontuação obtida até ao momento com os valores mínimo e máximo que poderia ter acumulado se acertasse ou errasse em todas as jogadas do bloco.

Lembre-se que o/a participante que obtiver a melhor pontuação no final do estudo receberá um voucher adicional no valor de 5€!

Para se familiarizar com a tarefa, vamos apresentar-lhe de seguida 3 jogadas de treino.

Appendix F
Feedback given for each option of response

Item belongs in "List Category" or item belongs in "other Category" - correct feedback.

A sua resposta está certa!

Nesta jogada ganhou 5 pontos!!

Item belongs in "List Category" or item belongs in "other Category" - incorrect feedback

A sua resposta está errada!

Nesta jogada perdeu 10 pontos!!

"I don't know/ I don't want to respond"

Escolheu não responder esta jogada!

Nesta jogada não ganhou nem perdeu pontos.

Appendix G
Scoring tables/end block feedback

Fim do Bloco 1

Síntese da sua pontuação

Neste bloco obteve X pontos.

Caso tivesse errado ou acertado em todos os ensaios deste bloco a sua pontuação neste momento seria, respetivamente:

Pontuação mínima	**Pontuação máxima**
-480 pontos	240 pontos

Fim do Bloco 2/3/4

Síntese da sua pontuação

Neste bloco obteve X pontos.

A pontuação acumulada dos blocos é: X pontos

Tendo em conta a sua pontuação nos blocos anteriores, caso tivesse errado ou acertado em todos os ensaios deste bloco a sua pontuação neste momento seria, respetivamente:

Pontuação mínima	**Pontuação máxima**
X pontos	X pontos

Appendix H
Instructions given on the fourth test block

Mandatory condition

Vamos agora dar início ao último bloco deste jogo. A sua tarefa neste bloco continuará a ser indicar se cada uma das palavras apresentadas pertence ou não à categoria LISTA. A única diferença em relação aos blocos anteriores é que neste bloco não receberá informação acerca dos pontos ganhos ou perdidos após cada jogada.

Optional Condition

Vamos agora dar início ao último bloco deste jogo. A sua tarefa neste bloco continuará a ser indicar se cada uma das palavras apresentadas pertence ou não à categoria LISTA, mas desta vez não terá disponível a opção "Não sabe/Não responde". Outra diferença em relação aos blocos anteriores é que neste bloco não receberá informação acerca dos pontos ganhos ou perdidos após cada jogada.

Appendix I
Questionnaire

De seguida vamos apresentar-lhe uma síntese da pontuação acumulada ao longo do jogo. Antes disso gostaríamos de colocar algumas questões sobre este último bloco de jogadas.

Usando a escala abaixo, indique como classificaria o seu desempenho no último bloco de jogadas.

Muito mau	Mau	Suficiente	Bom	Muito bom

→

A tabela abaixo apresenta os valores mínimo e máximo de pontos que poderia ter obtido neste bloco caso tivesse errado ou acertado em todas as jogadas.

Pontuação mínima no bloco	Pontuação máxima no bloco
- 480 pontos	240 pontos

Tendo em conta os valores apresentados, quanto estima ter sido a sua pontuação neste bloco?

→